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ABSTRACT

An examination of task analysis from several perspectives in order to identify some of its purposes and advantages reveals that, as the interest in learning theory has shifted from a predominately behavioral perspective to a more cognitive orientation, the purpose of task analysis has also shifted. Formerly the purpose of task analysis was to aid in instructional design by identifying and classifying component behaviors which could accumulate into a terminal performance. However, cognitive and information processing theorists have not been so interested in the component behaviors as in the cognitive activity that occurs between these behaviors. Thus the emphasis on task analysis has shifted from behavioral outcomes to the analysis of cognitive processes. Three cognitive approaches to task analysis are (1) the optimal content structure approach, (2) the learner-content match approach, and (3) the optimal content presentation approach. Although task analysis has been approached from several perspectives, there is agreement among all the theorists on at least one point: Task analysis, at a minimum, assists the instructor or designer to understand the content to be taught. This alone is a sufficient reason for recommending task analysis. (Author/LLS)

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Linking Task Analysis with Student Learning

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The current controversy surrounding task analysis, while not heated, may lead to some confusion. It appears to be widely recognized that some form of content structuring is an essential part of the instructional design process. However, there is little consensus on how content should be structured, what the proper focus of these structuring activities should be, how what is structured relates to what students must learn, or how any or all of the above relate to teaching practice or methods. There appear to be two major questions associated with these issues: 1) Exactly what is task analysis? and 2) What purpose does a task analysis serve? One difficulty in responding to these questions is that there are many correct answers depending upon one's position in the task analysis controversy. We will examine task analysis from several perspectives in order to identify some of the purposes and advantages of task analysis.

Task Analysis and Theory

As the interest in learning theory has shifted from a predominately behavioral perspective to a more cognitive orientation, so too has the role and purpose of task analysis shifted. In 1974 Gagne stated that "Task analysis was proposed as a method of identifying and classifying the behavioral contributors to task competence, for which differential instructional design was possible and desireable" (p. 3). This statement seems to imply a relatively straight forward series of contributors or component behaviors which could accumulate into a terminal performance. The reason for conducting a task analysis from this perspective rests on a relatively direct link between the behavior being taught and necessary instructional conditions. Identification of the component behaviors leads directly to the identification of instructional or learning conditions which effectively define necessary instructional activities. Gagne and Briggs (1974, pp. 148-149) included

tables in their text on instructional design which coordinated the type of learning with these learning conditions.

However, cognitive and information processing theorists have not been so interested in the component behaviors as in the cognitive activity that occurs between these behaviors. As Resnick and Glaser (1976) stated, "It is probably not too extreme to argue that the most interesting events, in terms of a theory of intelligence, happen between the specified points in a hierarchy" (p. 207). Resnick (1976) defined task analysis as "the study of complex performances so as to reveal the psychological processes involved" (p. 51). In other words, the emphasis shifted from behavioral outcomes to the analysis of cognitive processes. This concern for process is evident in Winn's (1978) statement that "it is necessary for the designer to know the structural relationships between the concepts that form the content to be learned" (p. 4). While providing a richer theoretical understanding of learning, the cognitive approaches have been less than clear on how the analyzed processes may be linked with learning. In part, this is due to the variety of possible strategies any individual may employ in solving a specific problem. In part, the problem stems from the focus on identifying meritorious or expert processes rather than on specific instructional strategies leading to the learning of these processes.

The development of instructional materials or learning strategies has not been well described in most cases by cognitive psychologists. Frequently, the linking of content and learner is summarily passed over as when Winn (1978) stated, "The final design decisions leading to scripting materials to be produced, and decisions concerning the instructional strategies to follow are very similar to those followed in the traditional procedures of instructional development" (p. 15). It is difficult to believe that the fundamental changes in content analysis proposed by cognitive psycholo-

gists could be delivered in the same old or "[illegible]nal" way. In fact, they can't; it appears that a new catalog of i[illegible]onal links are needed to teach processes rather than outcomes. The rema[illegible] of this paper will be devoted to an examination of three approaches to content structuring. In doing so, we will identify the explicit or implicit links which may be used to tie structured content to student learning

Approach 1: The Optimal Content Structure Approach. Most information processing appraoches propose an expert or idealized model of the cognitive processes needed to perform a specific operation. The result is a detailed description of an "idealized performance - one that solves the problem in minimal moves, does little 'backtracking,' makes few or no errors (Resnick, 1976, p. 65). Content structures may be generated either empirically or rationally. The major difference is that the rational approach is derived from the inherent structure of the subject matter by an analyist. An empirical structure is a description of the process used by an expert to solve the problem. In both cases, the result of the analysis is an hypothesized structure which describes the necessary processes in a sequential order. A noteworthy example of an optimal content structure approach is Resnick, Wang and Kaplan's (1973) description of an hierarchy for a mathematics curriculum.

These analyzed structures represent an ideal arrangement of component processes and are ordinarily quite dependent on the skill of the analyzer. The resulting hierarchy represents one of several possible paths a learner may take in solving a problem all of which lead to a correct solution. In addition, the method selected to validate the hierarchy may also influence the obtained structure. Kurshan and Sherman (19 7) found that three validating procedures (proportion of positive transfer; consistency, adequacy and completeness; and Guttman scaling) produced differing structures of

the same component skills. The major problem, recognized by Resnick (1976), however, is that the teaching of the ideal routine or process may not be the best way to learn the process. Instead, it may be more productive to teach simpler routines from which learners generate more efficient and sophisticated routines.

The value of this sort of task analysis appears to be that "we can generally do a better job of accomplishing something and determining how well we have accomplished it when we have a better understanding of what we are trying to accomplish" (Greeno, 1976, p. 123). In other words, once the goal of instruction is clear, it is possible to identify several strategies that may be used to reach it.

The link between the ideal structure and learning, must be the teaching routine. Resnick (1976) discussed this problem as identification of "the connecting link between the structure of the subject matter and skilled performance - which is often so ellyptical as to obscure rather than reveal the basic structure of the task" (p. 74). Unfortunately, the specifics of this linking process are unclear and the best advice is quite general in nature. The best of this advice seems to be to present all strategies as alternative procedures and not as specific rules. That is, a process should be taught as a beginning point from which further learner elaboration and experimentation is expected. Perhaps this could be done by continually challenging students to invent and discover other strategies.

The instructional designer faces two problems; what to teach and how to teach it. The solution to neither problem is greatly facilitated by the optimal content structure approach. However, this form of task analysis does not greatly complicate the problem either. In fact, a well developed structuring of content could serve several purposes. At a curriculum guide level, an optimal content structure could provide a useful guide to teachers of the cognitive topography of the subject matter. While day to day instruc-

tion would not be impacted directly, the general purpose of instruction could be regularly directed toward the development of expert processes. At the daily instruction level, it would seem the best advice for linking the structured content to learning may be through the use of process models. Greeno (1976) gave a brief example of how this might be done in describing how he taught the process of proving congruent angles are equal (also see Greeno, 1978).

Approach 2: Learner - Content Match Approach. Faithful applications of Piaget's theory to instruction have been extremely rare. In two recent articles, Case (1976a, 1976b) has articulated some of the problems associated with the application of Piaget's theory and advanced a useful formulation for the development of instruction based on Neo-Piagetian ideas. The basic premise upon which this instructional approach is based is that the demands of the content must be consistent with the competence of the learner. Thus, there is a need to bring content and learner into harmony.

Case (1978a) identified two problems which must be solved in order to develop developmentally based instruction: 1) How may the development of operational structures be promoted? 2) How may content be adapted to the student's operational level? A three step instructional design process is proposed consisting of: Structural Analysis, Individual Assessment, and Instructional Planning. Structural Analysis is quite similar to an information processing analysis of the empirical sort. That is, the process used by an expert is analyzed into identifiable operations. The emphasis in structural analysis is on the competence that the learner must possess in order to perform or solve the problem. The second step, Individual Assessment, focuses on the identification of operations that the learner actually uses in solving the problem. The purpose for the assessment is to discover the incorrect strategy the learner employs while attempting to solve the

problem. The procedure suggested for this analysis is the same as used during the structural analysis.

Step 3, Instructional Design, provides the link between the learner's current routine and the ideal routine as identified in Steps 1 and 2. Case focuses the instructional design on four potentially controllable variables drawn from Neo-Piagetian theory: M-power (the maximum number of independent schemes which can be attended to at any moment), the familiarity of the situation, the salience of cues to which the learner attends, and the number of items of information that must be coordinated. Five steps are included in this design process in order to arrange the above variables in an effective manner. The first is to "set up a paradigm where the subject may assess the effectiveness of the strategy that he currently employs" (Case, 1976a, p. 209). Here familiarity and cue salience should be maximized and cognitive complexity minimized in order not to confound the identification of the currently used strategy. The second step is to demonstrate to the learner the ineffectiveness of the strategy he uses. Step 3, involves helping the learner discover why his strategy is ineffective. Here the intent is to draw the learner's attention to the critical dimension (cue salience, familiarity, complexity) which must be attended to in order to solve the problem. The correct solution should be demonstrated and compared with the learner's incorrect strategy. Step 4 is to "facilitate (the learner's) construction of a more adequate strategy" (Case, 1976a, p. 211). The new strategy may be constructed spontaneously but more likely will need to be taught. The final step, is to consolidate and extend the new strategy through practice and feedback. Through practice the new strategy becomes "automatized" and requires less attention and energy during execution.

This link, while very complete, theory based, and well detailed; is quite cumbersome and tedious. Utilization of the instructional design

process advocated would almost be disastrou a context where extensive pre-planning is required for instructional delivery. In fact, the instructional methods described by Case closely follow the clinical methodology techniques which have become synonomous with Piagetian theory. Clinical approaches to teaching are well suited to clinical settings but difficult if not impossible in regular instructional situations. Case (1976a) also recognized this problem and suggested that the procedure he described was, in fact, most applicable in clinical situations.

Relative to curriculum development this approach is not especially helpful since the major focus is on cognitive strategies. Curriculum design usually revolves around content and either an inherent or generated structure of that content. It is conceivable and even appealing to consider curriculum structured around cognitive strategies, but this appears to be unlikely since a major reorganization of education would be required.

Approach 3: Optimal Content Presentation Approach. Gehlbach (1979) criticized the ATI approach to theory building because of the prescriptive orientation generally pursued. He suggested a more generalizable approach where ATI are used as dependent measures and instructional methods are independent measures. Flat AT regression curves would be indicative of no interaction and identify "generally powerful" instructional treatments. In essence, Gehlbach suggested that ATI's be rendered impotent by exceptionally powerful instruction thus negating the differential effects of aptitude variations. Instructional strategies of this sort should provide instructors with very high levels of control over learning through explicitly defined teaching routines and regular student responses. In essence the focus of the approach is on the link rather than the content. Two examples of this approach are drawn from the work of Landa (1976) and Englemann (1980).

Engelmann (1980) did not address the issue of content structure; his

approach may be more accurately described as instructional structure. The strategy is to structure the instruction in such a way that it cannot fail by attending to the instructional routine (the stimulus) rather than learner response as is traditionally done by behavioral psychologists. Engelmann (1980) presented five rules from which the effects of stimuli can be predicted on learner response:

1. Examples are classified as being the same in some way if they are treated in the same way by the teacher (labeled the same way).
2. Any observable sameness shared by all examples treated the same way describes a possible interpretation.
3. The set of teaching examples may describe only one interpretation or more than one interpretation.
4. Each interpretation implies classifying an indefinitely large number of "generalization examples" in a particular way.
5. The learner who receives a set of teaching examples will behave in a way that is consistent with <u>one</u> interpretation (Engelmann, 1980, p. 30).

Application of these rules should result in one of three outcomes: (1) if one example is taught, all learners will respond in the same way; (2) if more than one example is taught, each learner will respond to one of the interpretations; (3) generalizations may be expected to be consistent with the example(s) taught. Engelmann's point is that "the basic analysis for discriminations and concepts is performed on <u>a set of examples</u>, not the learner" (p. 32). Thus, the focus of analysis must articulate rules about the use of examples. The basic goal is to "<u>construct sequences or routines that are consistent with a single interpretation</u>" (p. 35).

Algorithms were defined by Landa (1976) as "instructions for the performance, in a particular order, of some system of elementary operations for solving all problems of a given class" (p. 77). Thus, knowledge of an algorithm enables a learner to correctly solve all problems within a problem domain. Since an algorithm is not a rule of itself but a description of the operations required to implement a rule, it may be thought of as a rule

for using a rule. It is also, from an instructional design perspective, an operation which follows or is in addition to a content analysis. That is, the rules to be taught must be identified and ordered prior to the development of specific algorithms to implement or teach these rules.

The potential power of an algorithm in instruction is based on the high level of control established over learner information processing. At every stage of problem solution the instructor can match student production with the algorithm. Through practice, algorithmic problem solution becomes less of a step-wise process and more "simultaneous" (Landa, 1976, p. 93). Thus, the algorithm is the essential link between the learner and the rule to be learned. It is a highly structured, guaranteed and easily operationalized construct which will always lead to the correct solution.

In both examples, it is clear that the teacher is advantaged by the identification of specific linking strategies. What is unclear is the manner in which the content to which the strategies are applied may be identified. Perhaps a "traditional" task analysis would serve the purpose. It is also possible this would not be the case when non-algorithmic content or concrete concepts were not the focus of instruction (e.g. democracy or problem solving, Greeno, 1978). Regardless, the quest for powerful and well structured instructional stimuli is well worth pursuing.

Conclusion

It appears that the link between content and learning is dependent upon several factors which are not inherent in task analysis. The theoretical approach of the instructional designer appears to be a major determinant. For the theoretical approach plays a large role in the nature of the content included in the task analysis. One may legitimately focus on inherent content structure, learner capabilities, and/or instructional

stimuli. However, two implications seem particulary noteworthy. First, it is imperative that task analysis be considered from a theoretical perspective. The theory appears to drive the whole instructional design process in that once a task analysis is completed, all subsequent instructional decisions should be consistent with the analysis approach. An understanding of theory may be the only way to generate such consistency. Second, structure of some sort is vital to successful instruction. If what is to be learned is not purposefully organized, generally lower rates of learning may be expected. Purposefullness appears to be a key issue in developing structure. That is, the content should be specifically structured to teach concepts and/or strategies and/or routines, etc. Failing to do so may result in students not learning what was intended. Finally, from all perspectives, it seems clear that there is agreement that task analysis, at a minimum, assists the instructor or designer understand the content to be taught. This alone is probably a sufficient reason for recommending the analysis and structuring of content. That is, the ultimate link may be that the teacher understands what he or she is teaching.

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